looked upon as something conveying energy along the conductor. This part of the subject, although deduced from the present theory, is shown to be true on Professor Poynting's own premisses.

It is well here to call attention to what might prove confusing otherwise. In what follows E, e, F, Φ, and some allied symbols stand for certain external forces. But there are three different meanings given in different parts of the paper to these symbols. They are originally defined as the whole external forces of the different types. But in treating of frictional forces, &c. (§§ 35 to 42), it is convenient to regard them as meaning only those parts of the forces which are *due to* friction and the like. Again, from § 50 onwards, it is convenient to regard them as meaning only those parts of the forces which are *independent of* friction and the like. This inconvenience is incurred to avoid the greater evil of a large additional array of symbols.

With this exception,* and one or two other trifling ones, which are noticed in their places, nowhere has the meaning of a symbol been changed throughout the paper.

IV. "Stellar Photometry." By W. J. Dibdin, F.I.C., F.C.S., &c. Communicated by A. Vernon Harcourt, F.R.S.

Received February 23, 1892.

(Abstract.)

Hitherto the determinations of stellar luminosity have been made solely with regard to the relative intensity of the stars apart from any reference to a known terrestrial unit. The various methods which have been employed do not denote actual intensity, and the present inquiry was, therefore, undertaken with the view of elucidating this question, especially with regard to those stars whose colour has presented a difficulty.

As a preliminary, the author prepared a standard series of artificial stars of various colours and known intensity, in terms of the English standard candle. These range in value from one candle to 0·000018 candle, and when placed at a distance from the telescope form a standard series for comparison.

The evaluation of the coloured lights was made by means of the author's modified "star" disc, by the use of which comparisons of various coloured lights can be readily obtained.

* Since completing the paper I have discovered a notable exception, which is *not* otherwise noticed than in this foot-note. It does not seem likely to lead to confusion; therefore I retain it. Most frequently in the present paper q stands for the typical *scalar* coordinate of a dynamical system, but it is not infrequently used, as in the former paper, for the *quaternion* of the rotation-operator $q(\ )q^{-1}$.

The second portion of the inquiry was directed to the most suitable means of comparing a star with the standard. Such a method must provide for the estimation of the total luminous energy, irrespective of the fact that in the case of a star the light practically emanates from a point, whilst that from the standard emanates from a surface. This fact precludes the use of the wedge photometer.

The methods employed by the author were three in number. The first was by means of reflection from a plane mirror mounted in front of the telescope object glass, in such a manner that the light of one of the radiants is seen by reflection through one half of the lens, whilst that of the other is viewed through the other half, by direct vision, both radiants being thus simultaneously seen in the same field of view. When the two images are placed out of focus to an equal extent, so as to be equal in size, comparisons of intensity can be made. By this system it matters not whether the light emanates from a point or a surface, as it is the degree of illumination of the respective portions of the object glass which is measured. Errors due to the unequal transmitting power of the different portions of the lens, and also those due to the loss of light by reflection, &c., are corrected by repeating the observations after the whole of the apparatus has been reversed; *i.e.*, if the star is seen by reflection in the first observation, it is to be viewed by direct vision in the second, when the standard light will be viewed by reflection.

The second method employed was a modification of Zöllner's lamp, the standard used being the author's pentane Argand burner, in which air carburetted with pentane is employed as a combustible. This is mounted on the eye-end of the telescope. Next to the burner is placed a plate of ground blue glass, carefully adjusted to reduce the colour of the gas flame, so that it is, as nearly as possible, comparable with that of daylight. This glass is mounted permanently in front of an aperture, 0·08 inch in diameter, in a brass plate. At a distance of 2·4 inches from this is placed a second plate of brass, having an aperture of 0·013 inch diameter. A lens, fixed at 2 inches from this second plate, projects the image of the illuminated surface of the blue glass by a reflecting prism, to the eye-piece of the telescope, in which it is viewed as a circular disc of light, side by side with that caused by the illuminated image of the telescope object glass. The ground surface of the blue glass affords a slightly granulated appearance, exactly imitating that of the object glass when a star is viewed out of focus. By arranging the position of the eye-piece until the two images are exactly of the same size, the imitation of a star is so striking that it is all but impossible, when the colours are alike, to discern the difference.

For the modification of the colour of the comparison light, two series of coloured glasses are arranged in rotating diaphragms situated

between the two perforated plates 2·4 inches apart. These can be conveniently brought into position for modifying the colour and intensity of the comparison light. The coefficient of absorption of each of the coloured glasses was determined photometrically, and tables prepared by reference to which corrections for their use can be made.

As this method was found to present an objectionable feature in regard to the uncertainty attending the use of multiple glasses for reducing intensity, the third method was employed. The lamp was placed on a graduated bar in such a manner that its distance from the ground blue glass could be conveniently altered, and the illumination of that glass reduced on strictly photometrical principles. This method was found to answer so well that the experimental apparatus first employed is being altered and improved. When it is completed, a further and extended series of observations will be made. In the meantime, the results already obtained may be discussed.

Details of the observations are given in the tables presented with the paper. By plotting the average results on a diagram a mean curve is drawn. From the value thus found, the relative intensity of stars of all other magnitudes can be calculated.

It then only remains to convert the comparative into actual values by the correction for the distance of those stars whose positions are known, when their actual intensities will be ascertained.

The following series is given of the average results of the determinations of the intensity of a sequence of stars in descending order of brightness, together with their respective magnitudes, and a comparison of their theoretical intensities on the assumption that a second magnitude star equals 0·00075 candle placed at a distance of 109 feet, which factor is deduced from the mean curve of all the determinations made :—

Average Results by Methods 1, 2, and 3.

Star's designation.	Magnitude. Pritchard.	Illuminating power found. Candle at 109 feet.	Theoretical illuminating power on the assumption that mag. 2 = 0·00075 candle at 109 feet.
Vega	+0·86	0·0039	0·0041
Capella	0·08	0·0017	0·0020
Aldebaran	1·12	0·0015	0·0017
γ Orionis	1·79	0·00075	0·00090
β Tauri	1·79	0·00085	0·00090
β Aurigæ	1·94	0·00125	0·00080
δ Orionis	2·02	0·00074	0·00074
Polaris	2·05	0·00081	0·00072
α Andromedæ	2·05	0·00085	0·00072
β Ursæ Minoris	2·26	0·00045	0·00059
γ Cygnus	2·26	0·00035	0·00059
α Pegasi	2·33	0·00062	0·00055
γ "	2·47	0·00031	0·00048
γ Andromedæ	2·72	0·00042	0·00038
θ Aurigæ	3·03	0·00018	0·00029
γ Ursæ Minoris	3·02	0·00029	0·00029
ε " "	4·46	0·000040	0·000080
δ " "	4·54	0·000044	0·000070
ζ " "	4·65	0·000025	0·000065
B.A.C. Cat. 6754 Cygni	5·27	0·000015	0·000037
24 Ursæ Minoris	5·87	0·000013	0·000021

The atmospheric absorption of light is discussed, and instances given of the considerable diminution in the light of a star when no apparent cause was discernible to ordinary observation.

Eight determinations of the light of Jupiter have been made, the average result being to ascribe to that planet a light equal to 0·020 candle placed at a distance of 109 feet. Determinations of the light of the planet Venus and of the Moon are also given, and the necessity for further observations referred to.

The total quantity of light afforded by the stars (apart from the planets) is calculated from the above results combined with Argelander's estimate of the number of stars down to the ninth magnitude. Assuming that the light afforded by these is equalled by the innumerable stars of lesser magnitude than the ninth, and by nebulæ, total starlight will equal that from 1·446 candles when placed at a distance of 109 feet. If it be further assumed that only one-sixth of the stars are capable of illuminating a given surface at the same moment, then such illumination will be equal to that afforded by one standard candle placed at a distance of 210 feet.